SB761
U7I5
#93-4

MAR 23 1993

United States Department of Agriculture | Forest Service | Intermountain Region | 324 25th Street Ogden, UT 84401

Reply to: 3420 Date: March 13, 1993

Subject: A Biological Evaluation "A Douglas-fir Tussock Moth Hazard Rating for Use in Southern Idaho."

To: Chief, WO

Enclosed is a biological evaluation entitled "A Douglas-fir Tussock Moth Hazard Rating for Use in Southern Idaho."

copies contact: Forest Pest Management
Boise Field Office
1750 Front St. Room 202
Boise, ID 83702

Ralph E Williams

for LAURA B. FERGUSON
Director, State and Private Forestry

Enclosure

cc:
Forest Supervisors, R-4
District Ranger, Weiser RD Payette NF
District Ranger, Mtn. Home RD, Idaho City RD, Emmett RD, Cascade RD BNF
District Ranger, Lowman RD BNF
District Ranger, Fairfield RD, Kethcum RD, Sawtooth NF
BLM, Ray Brainard, Pocatello Resource Area
Intermountain Research Station, Robert Steele Boise
OFO
TM-R4
State Entomologist, State of Idaho
Canadian Forestry Service, Victoria, BC
BCC Timber & Wood Products
FPM, MAG
FPM - R1, R2, R3, R5, R6, R10
Forestry Sciences Laboratory, INT, Moscow, ID
Library, INT, Ogden, UT
PNW, Portland, OR; PSW, Berkeley, CA; RM, Ft. Collins, CO
State Director BLM, ID
Hugh Homan, Entomology Dept. Univ. of ID

LIBRARY COPY
ROCKY MTN. FOREST & RANGE
EXPERIMENT STATION

3420
Report No. R4-93-04
March 12, 1993

A DOUGLAS-FIR TUSSOCK MOTH HAZARD RATING SYSTEM FOR USE IN SOUTHERN IDAHO

By

Julie C. Weatherby[1]
Brian R. Gardner[2]
Tom N. Barbouletos[3]

ABSTRACT

This report documents our efforts to develop a 2 phase hazard rating system which could be used by land managers to predict the likelihood of a Douglas-fir tussock moth outbreak in a particular stand (phase 1 - probability of occurrence) and the anticipated damage which may occur (phase 2 - vulnerability). Relative outbreak probabilities defined as highly likely, likely, or possible but infrequent, are assigned to broad geographical areas based upon historical outbreak frequencies. All timbered stands within each geographical area are assigned a likelihood value or probability of occurrence associated with that geographical area. Relationships between site and stand characteristics and damage levels as measured by defoliation intensity are evaluated. Site and stand characteristics with the strongest relationships to damage are used to develop a procedure to classify stands into one of 3 vulnerability rating classes. Classification accuracy using this procedure is 65 percent for stands used to develop this procedure and 68 percent for an independent group of stands.

[1] Entomologist, Forest Pest Management, Intermountain Region, USDA Forest Service.
[2] Biological Technician, Forest Pest Management, Intermountain Region, USDA Forest Service.
[3] Forester, Forest Pest Management, Intermountain Region, USDA Forest Service.

INTRODUCTION

The Douglas-fir tussock moth, *Orgyia pseudotsugata* McDunnough (DFTM), is a serious defoliator of Douglas-fir and true firs in western North America. Populations cycle periodically, rapidly increasing from endemic to outbreak levels. Outbreak cycles usually last 3 to 4 years before the population collapses as a result of a combination of mortality factors, including parasites, predators, diseases, and starvation.

Tussock moth populations overwinter in the egg stage. Egg hatch occurs after bud break in late May or early June. Small larvae disperse from egg masses redistributing themselves throughout the forest canopy. Long distance dispersal is accomplished when small larvae spin down from branches and are passively blown by winds. Such dispersal is usually limited to a distance of approximately 1/4 mile (Wickman et al. 1981).

Larval stages feed first on new foliage and move to older foliage after the new foliage has been consumed. When populations are extremely dense, trees can be almost completely defoliated in 1 year. Larval feeding occurs over a period of 40 to 60 days. Full-grown larvae seek out pupation sites during late July or August. Pupal cocoons are usually found on the undersides of branches; however, when populations are extremely dense, increasing numbers of larvae seek out other pupation sites such as tree trunks, rocks, fence posts, etc. Pupal cocoons consist of grayish, silken coverings each surrounding a single pupa.

Male moths begin emerging from pupal cocoons in August followed by the emergence of female moths. Male moths are gray-brown to black-brown with a wingspan of approximately 1 inch. Large, plumose antennae are conspicuous. Female moths are flightless and remain on or near their pupal cocoons for the duration of their lifespan. Females produce a pheromone which attracts males for the purpose of mating. Oviposition of eggs occurs directly on top of the pupal cocoon from which the female emerged. An average egg mass contains 150 to 200 eggs.

Feeding by DFTM results in varying degrees of defoliation. Light defoliation can cause top-kill and growth reduction. Heavy defoliation may culminate in tree mortality. During the 1990 - 1992 tussock moth outbreak in southern Idaho, we predicted that tree mortality resulting from very heavy defoliation could be as high as 73 trees per acre (Weatherby et al. 1992). Impacts of this magnitude significantly alter timber production and future management plans.

In southern Idaho, periodic outbreaks have occurred. Tunnock et al. (1985) documented the occurrence of several DFTM outbreaks between 1927 and 1984. Many of these outbreaks seem to reoccur in certain areas.

Researchers have recognized this pattern of reoccurrence and have attempted to predict where future DFTM outbreaks may occur and where impacts may be most severe. Stoszek et al. (1981) developed a risk rating system using the following site and stand characteristics: physiographic location, depth of volcanic ash layer, site occupancy, age of host trees, and proportion of stand in grand fir. This model was developed from data collected in the Palouse Range of northern Idaho. Heller and Sadir (1980) developed a risk rating system which used standard photo interpretation techniques to extract site and stand characteristics from resource photography. Site and stand characteristics incorporated into the Heller and Sadir model include: elevation, percent slope, aspect, physiographic location, percent cover, average crown diameter, and percent cover in fir.

Data used to develop this model were collected from the Blue Mountains during the 1973 DFTM outbreak.

Neither of these models adequately address risk ratings for Douglas-fir habitat types which are some of the most frequently defoliated sites in southern Idaho.

This report documents our efforts to develop a simple risk rating or hazard rating system for use in southern Idaho.

METHODS

Our approach to developing a DFTM hazard rating system is a 2 phase approach. Phase 1 involves developing a method to determine the probability of an outbreak occurring in a defined geographical area. Phase 2 involves classifying stands where damage is expected to be significant.

Phase 1 – Historical outbreak frequencies were gleaned from the literature. Broad geographical areas where outbreaks have occurred approximately once every 7 to 10 years, once every 15 years and zero to one time within the last 30 years were defined and highlighted on a map of southern Idaho. Outbreak probabilities defined as highly likely, likely, or possible but infrequent, were assigned to each of the 3 broad geographical areas, respectively.

Phase 2 – Scientific literature and field observations indicate that several site and stand characteristics may be important components of a DFTM hazard rating system. For this study the following site and stand characteristics were investigated: habitat type, aspect, elevation, position on the slope, proportion of the basal area in host, stand structure (multi-storied, single storied), age and radial growth.

Site, stand and damage data used in this analysis were collected during 1991 and 1992 from 45 5-plot transects distributed throughout infested areas in southern Idaho. The sampling design and methods used to collect these data have been described by Weatherby et al. (1992).

Each site or stand characteristic was evaluated individually against an area damage index (ADI) measured at the same site. The procedures used to develop this ADI are described by Weatherby et al. (1992). The range of ADI's (0.00 - 4.00) obtained from all sampled areas was partitioned into the following area damage classes: non-defoliated (ADI = 0.00), lightly to moderately damaged (0.00 < ADI = 2.00), and heavily to very heavily damaged (2.00 < ADI = 4.00).

Continuous site or stand characteristics such as age, elevation, radial growth, position on the slope, and proportion of the stand basal area in host species, were plotted against area damage indices. Subjective interpretation of these scattergrams was used to evaluate possible relationships between site or stand characteristics and area damage indices. Site and stand characteristics which appeared to be unrelated to area damage indices were eliminated from further evaluation.

Discrete site or stand characteristics such as aspect, habitat type (Steele et al. 1981), and stand structure, and continuous characteristics, selected after the scattergram interpretation, were subjectively partitioned into classes and compared to area damage classes. Five stand frequency tables with rows representing stand characteristic classes and columns representing area damage classes were developed. Chi-square tests of significance were performed on all cross tabulations. Significant

characteristics ($p < .10$) were included in the vulnerability model. The vulnerability model is an additive model which is explained in the results sections of this publication.

After the vulnerability model was developed, an independent data set, collected from 20 stands within Logging Gulch on the Boise National Forest, was used to validate the model. Each stand was classified into one of 3 predicted vulnerability rating classes using the vulnerability model and the predicted vulnerability rating class was compared to the actual damage class measured in the field.

RESULTS

Historical records of tussock moth outbreaks in southern Idaho were used in the development of outbreak probabilities (Phase 1). Historical literature (Tunnock et al. 1985) documenting DFTM outbreaks indicates that frequencies of outbreaks vary by geographical areas. The most frequent outbreaks in southern Idaho occur in the Owyhee Mountains where 6 detectable outbreaks have occurred in the last 43 years. Another area where frequent outbreaks have been detected is a broad geographical area within the drainages of the Boise River. Outbreaks in this area have been detected 2 times in 30 years. Stringer Douglas-fir stands in several drainages east of Bellevue and Hailey have similar defoliation histories as stands within the Boise River drainages. Many new areas of defoliation were detected for the first time during the 1990 - 1992 outbreak. History indicates that outbreaks within these areas are relatively infrequent. Figure 1 is a map of southern Idaho highlighting the outbreak areas with similar defoliation frequencies.

Habitat type, aspect, elevation, and position on the slope are site characteristics which were evaluated as potential discriminating variables to classify expected damage or vulnerability (Phase 2).

Sample stands represented a range of 12 habitat types, 6 habitat types in the Douglas-fir series (PSME), 4 in the grand fir series (ABGR), and 2 in subalpine fir series (ABLA). The most commonly sampled habitat types were PSME/ACGL (Douglas-fir/mountain maple), PSME/BERE (Douglas-fir/Oregon grape), and ABGR/ACGL (grand fir/mountain maple). Heavy to very heavy defoliation occurred on 6 of the 12 habitat types. Table 1 displays the frequencies of stands cross classified by habitat type and damage class. A relatively broad range of habitat types were impacted by defoliation. No really clear trend or relationship is apparent for this cross classification. Additional data from the less well represented habitat types are necessary if relationships between habitat types and damage classes are to be understood.

Data were obtained from stands on all aspects. Defoliation was heaviest on the easterly and southeasterly facing slopes where 71 and 80 percent of the sample stands on those aspects were classified as heavily defoliated. Table 2 summarizes the frequencies of stands cross classified by aspect and damage class. In order to statistically evaluate whether aspect and damage are independent variable, 3 aspect classes were developed. Class 1 consisted of all stands with a northern, western or northwestern aspect. Class 2 consisted of all stands with a southern or southwestern aspect. Class 3 consisted of all stands with an eastern, southeastern or northeastern aspect. Two stands were deleted from the analysis because they were essentially flat and therefore were not assigned to one of the 3 aspect classes. A chi-square test of significance indicated that aspect class and damage class are not independent ($X^2 = 11.69$ with 4 d.f., $p < .05$).

Field observation indicated that defoliation was usually found across relatively sharp elevational

Figure 1. Areas in southern Idaho with a history of defoliation caused by DFTM.

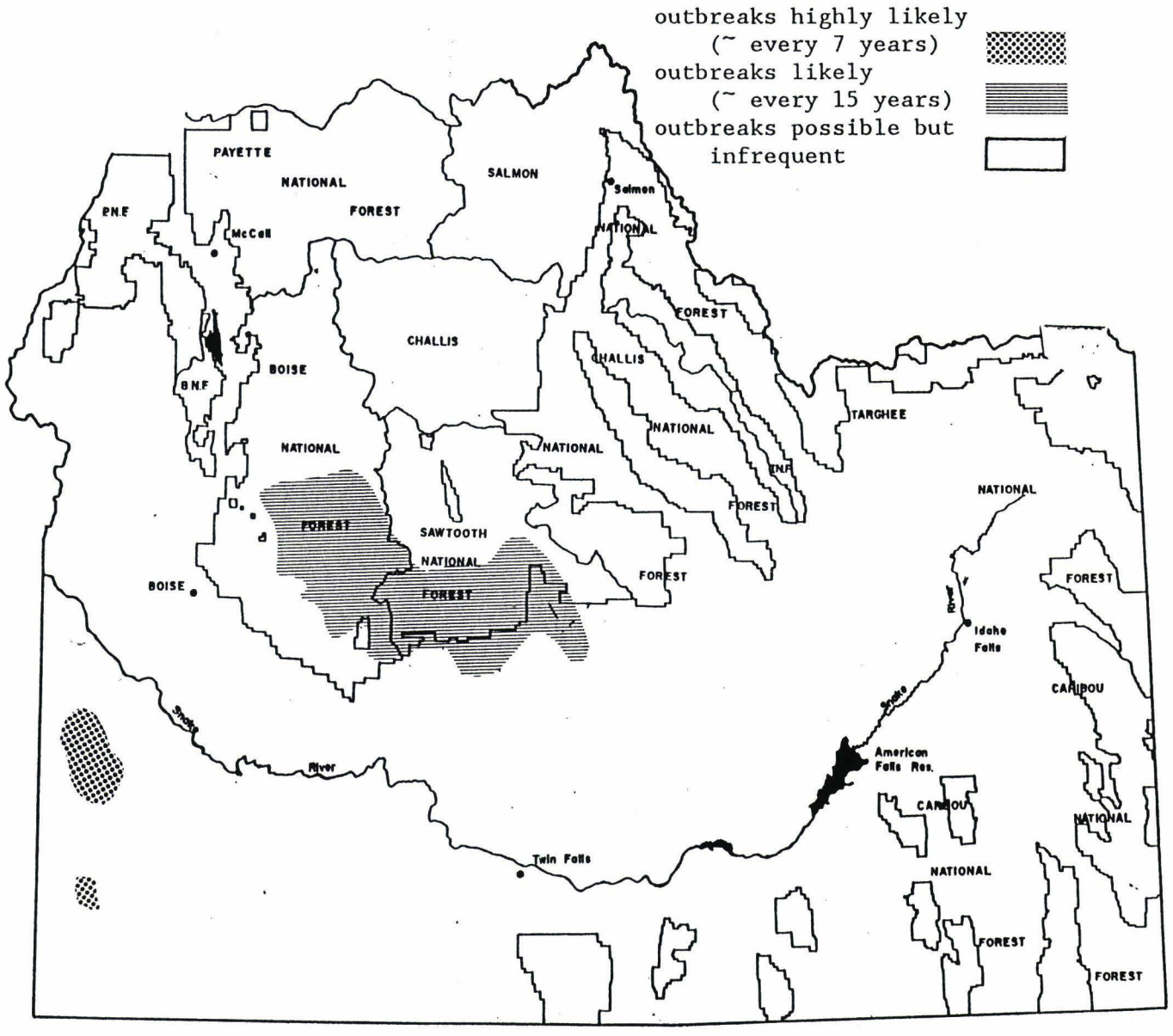

Table 1. Frequency table of sampled stands classified by habitat type and area damage class from the 1990 - 1992 DFTM outbreak in southern Idaho.

Habitat Type[a]	Area Damage Class			
	V. Heavy-Heavy	Light - Mod.	Non-defol.	Total
PSME/ACGL	3	7	0	10
PSME/BERE	6	3	1	10
PSME/CAGE	1	1	1	3
PSME/PHMA	0	0	1	1
PSME/SPBE	0	1	1	2
PSME/SYOR	0	1	0	1
ABGR/ACGL	4	4	0	8
ABGR/BERE	0	1	0	1
ABGR/SPBE	3	2	0	5
ABGR/VAGL	1	1	0	2
ABLA/ACGL	0	1	0	1
ABLA/CAGE	0	1	0	1
Total	18	23	4	45

[a] Habitat types as discribed by Steele et al. (1981)

Table 2. Frequency table of sampled stands classified by aspect and area damage class from the 1990 - 1992 DFTM outbreak in southern Idaho.

		Area Damage Class			
Aspect	Class	V. Heavy - Heavy	Mod. - Light	Non-defol.	Total
North	1	2	6	1	
West	1	1	3	1	
Northwest	1	0	3	0	
	Total	3	12	2	17
South	2	1	1	0	
Southwest	2	4	5	0	
	Total	5	6	0	11
East	3	5	2	0	
Southeast	3	4	1	0	
Northeast	3	2	1	0	
	Total	11	4	0	15
Total		19	22	2	43

bands. Therefore elevation was evaluated as a potential discriminating variable. Elevations of sample stands ranged from 4,800 to 8,850 feet while heavily defoliated stands ranged from 5,240 to 6,800 feet. None of the sample stands above 7,400 feet were defoliated. A scattergram (figure 2) of elevation and defoliation did not reveal any clear relationship. Because the sampled stands were located in at least 4 geographically separated areas which varied considerably in elevation, we decided to look at position on the slope. Position on the slope was defined as the elevation of each stand divided by the elevation of the forested ridgeline for the geographical area. If the ridgeline exceeded 7,400 feet, 7,400 feet was used as the ridgeline elevation. Ninety five percent of the heavily defoliated stands were located in an elevational band within 15 percent of the highest forested ridgeline for the area (table 3). A chi-square test of significance indicated that position on the slope and damage class are not independent ($X^2 = 15.72$ with 8 d.f., $p < .05$)

Proportion of the total stand basal area in host, stand structure, age and radial growth are stand characteristics which were evaluated as potential discriminating variables.

Approximately 70 percent of the sample stands had more than 85 percent of the total stand basal area in host species (Douglas-fir, grand fir, and subalpine fir). Forty two percent of these stands were heavily damaged. In stands with less than 85 percent of the stand basal area in host species, only 20 percent were heavily damaged. This information is displayed in table 4. A chi-square test of significance indicated that the proportion of the basal area in host and damage class are not independent ($X^2 = 4.81$ with 2 d.f., $.05 < p < .10$).

Stand structure defined as the number of stories of host trees within a stand was evaluated. Little if any relationship was apparent between stand structure and damage class.

Most of the sample stands were between 60 and 120 years of age. Within this range of ages all levels of defoliation were encountered (figure 3). None of the stands older than 120 years of age were significantly defoliated, however stands in this age category were probably under represented. Therefore this trend was not considered.

The last stand variable evaluated was 5-year radial growth. This variable was analyzed as an indicator of stress and growth potential of the site. Growth rates ranged from less than .10 to approximately .50 inches in 5 years. A scattergram (figure 4) of damage classes versus 5-year radial growth indicated little if any relationship between levels of defoliation and 5-year radial growth rates.

Eight site and stand variables were evaluated and only three, position on the slope, aspect class, and basal area in host species, were significantly related to damage classes. Each of these variables were included in the stand vulnerability model (table 5). Numerical values were assigned to each site and stand variable class. For example, position on the slope was divided into 3 classes. A numerical value of 3 indicating a high degree of vulnerability was assigned to the class ranging between 86 percent of the slope and the ridgeline; a numerical value of 2 indicating a lesser degree of vulnerability was assigned to the class ranging between 76 and 85 percent of the slope, and a numerical value of 1 was assigned to the least vulnerable class ranging between 0 and 75 percent of the slope. Similar numerical values were assigned to the aspect classes and the basal area classes. In order to determine the vulnerability of a stand, the position on the slope, the aspect class, and the percent basal area in host must be known. Appropriate numerical values associated with these characteristics are summed to obtain a composite rating ranging between 3 and 8. Composite

Figure 2. Scattergram of elevation versus area damage index associated with sampled areas within the 1990 - 1992 DFTM outbreak in southern Idaho.

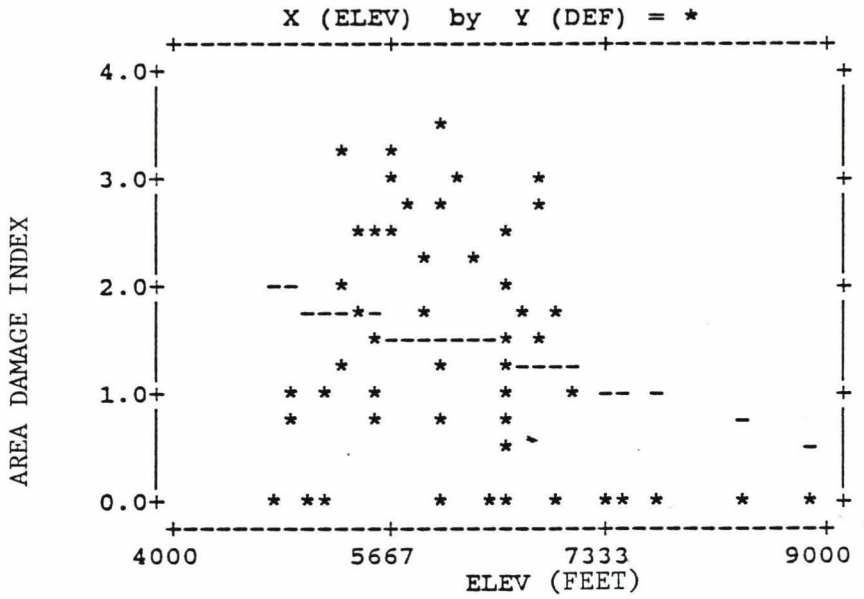

Table 3. Frequency table of sampled areas classified by position on the slope and area damage class from the 1990 - 1992 DFTM outbreak in southern Idaho.

	Area Damage Class			
Slope Position	V. Heavy-Heavy	Mod. - Light	Non-defol.	Total
0 - 75 %	0	2	3	5
76 - 85 %	1	5	0	6
86 - 100 %	18	16	0	34
Total	19	23	3	45

Table 4. Frequency table of sampled areas classified by percent of total stand basal area in host and area damage class from 1990 - 1992 DFTM outbreak in southern Idaho.

	Area Damage Class			
% BA in Host	V. Heavy-Heavy	Mod. - Light	Non-defol.	Total
0 - 85 %	3	11	1	15
86 - 100 %	16	12	2	30
Total	19	23	3	45

Figure 3. Scattergram of stand age versus area damage index associated with sampled areas within the 1990 - 1992 DFTM outbreak in southern Idaho.

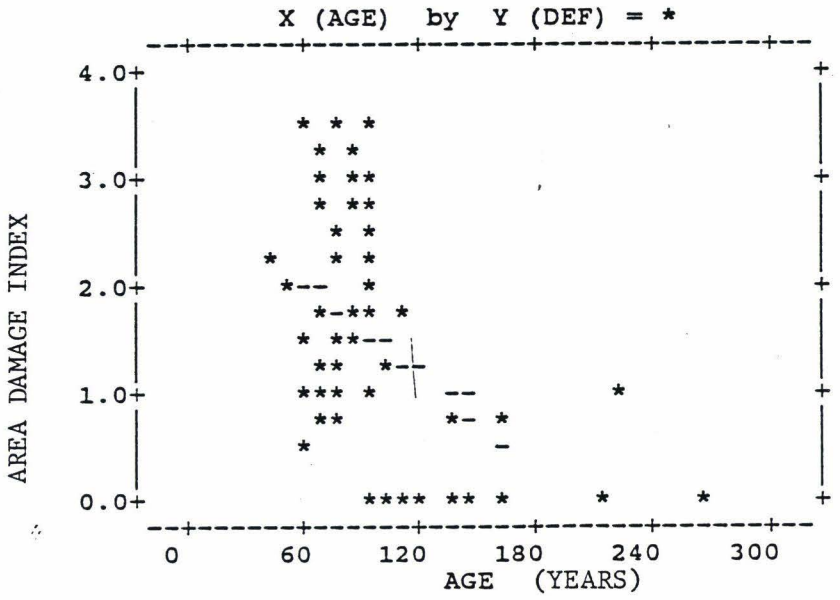

Figure 4. Scattergram of 5 year radial growth versus area damage index associated with sampled areas within the 1990 - 1992 DFTM outbreak in southern Idaho.

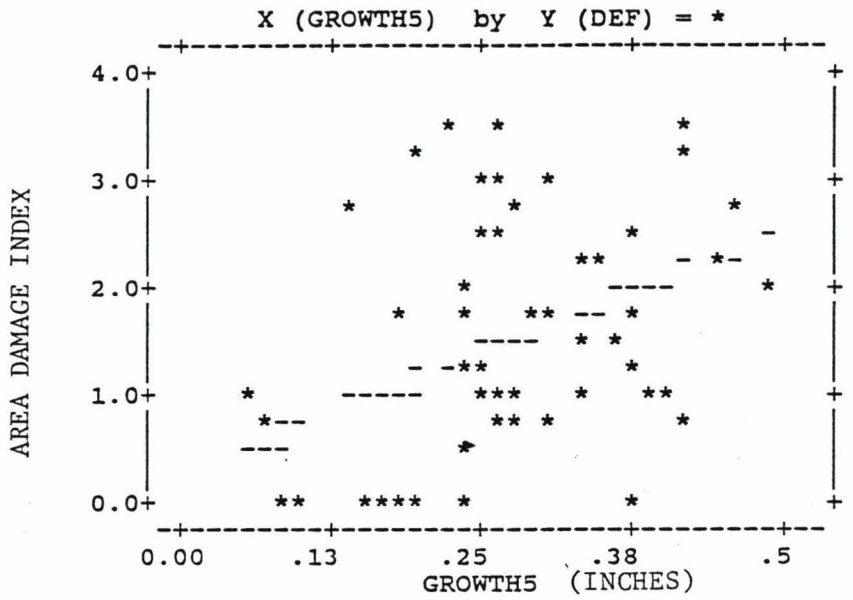

Table 5. Vulnerability model used to predict damage in infested DFTM stands.

Aspect	Position on slope[a]	% Basal Area in host
E, SE, NE (3)	.86 - 1.00 (3)	.86 - 1.00 (2)
S, SW (2)	.76 - .85 (2)	.00 - .85 (1)
N, W, NW (1)	.00 - .75 (1)	

[a] Position on the slope is defined as the elevation of the stand divided by the elevation of the highest forested ridgeline in the area. If the highest forested ridgeline exceeds 7,400 ft, the ridgeline elevation defaults to 7,400 ft.

ratings of 7 and 8, 5 and 6, and 3 and 4 indicate high vulnerability, moderate vulnerability, and low vulnerability, respectively.

The vulnerability model is intended to be used to predict the vulnerability rating or a qualitative level of damage which could be expected if a DFTM outbreak were to occur in a particular stand. Highly vulnerable stands could sustain tree mortality as a result of defoliation. Moderately vulnerable stands are more likely to suffer top-kill and growth reduction with little tree mortality. Stands with low vulnerability are expected to suffer minor and usually temporary damage. The vulnerability model accurately classified 65 percent of the stands used to develop this procedure into appropriate vulnerability rating classes.

The same vulnerability model was used to rate an independent group of infested stands in the Logging Gulch drainage on the Boise National Forest. When the vulnerability rating classes, as predicted by the model, were compared to actual defoliation classes, the predicted vulnerability rating classes agreed with the actual defoliation classes 68 percent of the time (table 6).

SUMMARY

This 2 phase hazard rating system could be used by land managers to predict the likelihood of a DFTM outbreak in a particular stand and the anticipated damage which may occur. This information is expected to be useful for long and short range planning and to prioritize silvicultural treatments.

In order to hazard rate a stand, the probability of an outbreak must be estimated by locating the stand within an area with a known outbreak frequency. If the stand is located in an area where outbreaks are highly likely or likely then the expected impacts caused by a tussock moth outbreak could be predicted using the vulnerability model. Stands which are classified as highly likely to have an outbreak and which have a high vulnerability rating are of greatest concern. These stands could be prioritized as needing prompt treatment. Stands where outbreaks are possible but infrequent and vulnerability ratings are high would have a lower overall hazard rating because the probability of an outbreak is low. However these stands could suffer tree mortality if an outbreak were to occur. Stands where outbreaks are possible but infrequent and vulnerability ratings are low would have a very low priority for treatment.

Table 6. Vulnerability ratings for selected stands in Logging Gulch, Boise NF.

Comp.	Stand	Aspect	Rating	Pos. Slope[a]	Rating	% BA Host	Rating	Vul. Rating	Pred. Vul. Cl.	Act. Damage Cl.	
406	2	NE	3	.81	2	7	1	6	M	M	
	4	S	2	.84	2	0	1	5	M	M	
	17	E	3	.84	2	50	1	6	M	M	
	21	E	3	1.00	3	100	2	8	H	M	*
	28	N	1	.57	1	95	2	4	L	M	*
413	2	W	1	.90	3	63	1	5	M	M	
	4	W	1	.87	3	67	1	5	M	M	
	6	E	3	.84	2	68	1	6	M	M	
	21	E	3	.93	3	52	1	7	H	M	*
	23	N	1	.81	2	100	2	5	M	H	*
	24	E	3	.81	2	94	2	7	H	H	
	25	NE	3	.93	3	77	1	7	H	H	
	26	S	2	.93	3	66	1	6	M	M	
	29	NE	3	.81	2	88	2	7	H	H	
414	9	E	3	.85	2	45	1	6	M	M	
	118	W	1	.79	2	30	1	4	L	M	*
	120	E	3	.85	2	31	1	6	M	M	
	121	SE	3	.87	3	36	1	7	H	M	*
	122	SW	2	.87	3	83	1	6	M	M	

[a] Position on the slope is the elevation of a stand divided by the elevation of the forested ridgeline for the local area.

LITERATURE CITED

Heller, R.C.; Sader, S.A. 1980. Rating the risk of tussock moth defoliation using aerial photographs. USDA, For. Serv. Douglas-fir Tussock Moth Res. & Dev. Prog. Agric. Handbook 569.

Steele, R.; Pfister, R.D.; Ryker, R.A.; Kittams, J.A. 1981. Forest Habitat Types of Central Idaho. USDA, For. Serv., Int. For. & Range Expt. Station, Gen. Tech. Rpt. INT-114, 138 p.

Stoszek, K.J.; Mika, P.G.; Moore, J.A.; Osborne, H.L. 1981. Relationship of Douglas-fir tussock moth defoliation to site and stand characteristics in northern Idaho. For. Sci. 27:431-442.

Tunnock, S.; Ollieu, M.; Thier, R.W. 1985. Hostory of Douglas-fir tussock moth and related suppression efforts in the Intermountain and Northern Rocky Mountain Regions - 1927 through 1984. USDA For. Serv., Rpt. No. 85-13. Int. and North. Regions, Missoula, MT. 51 p.

Weatherby, J.C.; Knapp, K.A.; Gardner, B.R.; Roberts, J.; Mocettini, P. 1992. A biological evaluation of the Douglas-fir tussock moth outbreak in southern Idaho, 1991. USDA For. Serv., Rpt. No. R4-92-01. Ogden, UT. 51 p.

Wickman, B.E.; Mason, R.R.; Trostle, G.C. 1981. Douglas-fir tussock moth. USDA For. Serv. Forest Insect & Disease Leaflet 86. 10 p.